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Vega qualification flight VV01

European Space Agency
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ESA INAUGURATES ITS NEW SMALL LAUNCH VEHICLE

The European Space Agency (ESA) is about to conduct the qualification flight of a brand new launch vehicle for the third time in its history. After Ariane 1 in 1979, Ariane 5 in 1996, 2012 is the year of Vega.

Vega is designed to complement the family of European launchers already available from French Guiana with the Ariane 5 heavy-lift launch system and the Soyuz medium-class launcher introduced last October.

Vega is a three-stage solid-propellant vehicle with a liquid-propellant manoeuvrable injection module sized primarily to loft payloads of up to 1500 kg into polar low-Earth orbits at an altitude of 700 km. Its main objective is to provide Europe with a safe, reliable, competitive and efficient capacity for scientific and Earth observation payloads.

Vega will accommodate a wide range of missions – from 300 kg to 2500 kg – into a wide variety of orbits, from equatorial to Sun-synchronous. It can also carry single or multiple payloads depending on mission requirements.

This maiden launch, designated VV01, marks the completion of nine years of development by ESA and its industrial partners, with the support of the Italian and French space agencies, ASI and CNES. Seven ESA member states have contributed to the programme: Belgium, France, Italy, the Netherlands, Spain, Sweden and Switzerland.

The launch is scheduled for 10:00 GMT (11:00 CET; 07:00 local time) on 13 February from the Vega Launch Site (ZLV: Zone de Lancement Vega) at the Guiana Space Centre, Europe's Spaceport in Kourou, French Guiana. The launch window will last for 120 minutes.

The payload includes two Italian satellites – ASI's LARES Laser Relativity Satellite and the University of Bologne's ALMASat-1 – and seven CubeSat picosatellites provided by European universities: e-St@r (Italy), Goliat (Romania), MaSat-1 (Hungary), PW-Sat (Poland), Robusta (France), UniCubeSat GG (Italy) and Xatcobeo (Spain).

Vega's AVUM Attitude and Vernier Upper Module will reach a circular orbit at an altitude of 1450 km and an inclination of 69.5° to the equator in order to release LARES. Then, it will manoeuvre to lower the perigee to 350 km before deploying the other payloads.

The mission will qualify the overall Vega system, including the vehicle itself, its launch infrastructure and the operational procedures from the launch campaign up to the payload separation and disposal of AVUM.

Following this qualification flight, Vega operations will be handed over to Arianespace, which will also be in charge of selling Vega on the international launch market. ESA will be an early customer of Arianespace's new service through a commitment for five launches under the VERTA Vega Research and Technology Accompaniment programme. An initial rate of two launches per year is planned following the qualification flight.

1 THE VEGA LAUNCH SYSTEM

The Vega Launch System consists of two main elements, developed together for maximum efficiency: the Launch Vehicle, including all stages and the Payload Assembly Composite, and the ground segment to store, integrate and check the vehicle before flight.

Under the prime contractorship of ELV SpA (a joint venture of ASI and Avio), some 1000 people from more than 40 European industrial companies have worked on the Vega vehicle development.

1.1 General design of the launch vehicle

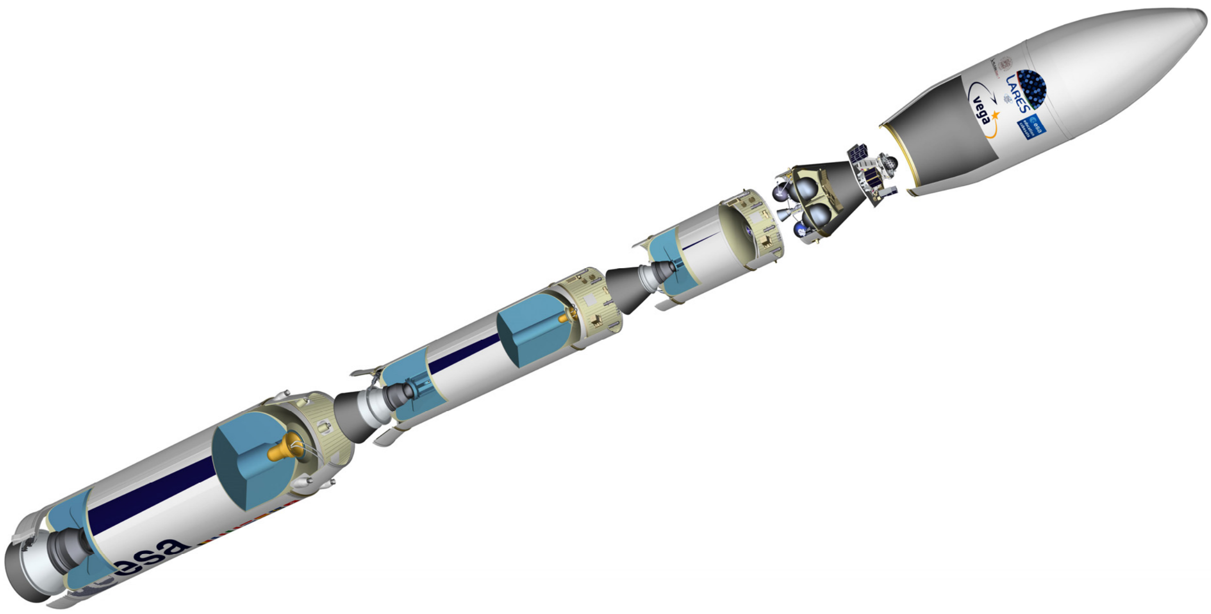
Vega is a single-body vehicle composed of three solid-propellant stages for the boost phase:

- P80FW first stage
- Zefiro-Z23 second stage
- Zefiro-Z9A third stage

The AVUM fourth stage provides mission versatility and accurate payload injection onto orbit.

The 2.6 m-diameter payload fairing accommodates single or multiple payloads.

Total mass at lift off is 136.7 tonnes; height is 30.1 m; the maximum diameter is 3 m.



Vega: P80 first stage, Zefiro-23 second stage, Zefiro-9 third stage, AVUM restartable fourth stage and upper composite.

Launch performance

The reference performance requirement for Vega is to inject 1500 kg into a circular 700 km-altitude orbit inclined at 90° to the equator, with an injection accuracy of 5 km in altitude and 0.05° in inclination.

The wide range of launch azimuths available from Europe's spaceport in Kourou, combined with the flexibility provided by AVUM, will enable Vega to deliver a wide range of payloads into different orbits, from 2500 kg to a circular near-equatorial orbit at 200 km, to 2000 kg towards the International Space Station or about 1300 kg into a 800 km-high Sun-synchronous orbit.

1.2 The P80FW stage and new technologies

The first stage of Vega is based on a large monolithic motor with a load of 88 365 kg of HTPB solid propellant. The motor delivers 2261 kN of thrust at sea level and burns for 114.3 seconds before being jettisoned at an altitude of 61 km.
The stage features two major new technologies in order to reduce the vehicle's mass:

- A carbon-epoxy filament-wound motor casing, the largest in the world for a monolithic motor;
- Electromechanical actuators for thrust vectoring, a world's first for a motor of this size.

Both technologies will be demonstrated and qualified on Vega in preparation for future launcher developments within ESA's Next-Generation Launcher (NGL) initiative.

The P80FW shares a 3 m diameter with Ariane 5's EAP solid boosters; its 11.2 m overall length is similar to one of EAP's largest segments. The same Ariane 5 facilities and equipment at the Guiana Propellant Plant, next to the spaceport, are used for the P80FW propellant loading and transport. The stage's nozzle is also an evolution from that of the Ariane 5 boosters.

Industrial team

APP (Netherlands)	Igniter
Avio (Italy)	Stage integration and test, loaded motor case
Europropulsion (France/Italy)	P80FW motor
Regulus (France/Italy)	Propellant loading
Sabca (Belgium)	Thrust vector control and stage skirt
SPS (France)	Nozzle

1.3 The Zefiro stages

Vega's second and third stages are based on Zefiro solid-propellant motors developed by Avio from its earlier Zefiro-Z16 ground-qualified motor. Both motors are 1.9 m in diameter with a carbon-epoxy filament-wound motor casing, low-density EPDM insulation and a flexible joint nozzle with electromechanical actuators for thrust vector control.

The 8.39 m-long Zefiro-Z23 is loaded with 23 906 kg of HTPB 1912 solid propellant and delivers 1196 kN of thrust at sea level. It burns for 86.7 seconds.

The 4.12 m-long Zefiro-Z9A is loaded with 10 115 kg of HTPB 1912 solid propellant and delivers a maximum thrust of 313 kN in vacuum. Although it is Vega's smallest solid-propellant motor, it has the longest burn time: 128.6 seconds. The Zefiro-Z9A also features the highest mass fraction for solid motors in this category.

The Zefiro stages are produced by Avio in its facilities in Colleferro, near Rome, Italy. They are loaded with solid propellant before their shipment to the spaceport.

Industrial team

APP (Netherlands)	Igniters
Avio (Italy)	Stages production, integration and test
Dutch Space (Netherlands)	Interstage 1/2
Rheinmetall Italia (Italy)	Interstage 2/3
Sabca (Belgium)	Thrust vector control

1.4 AVUM

The Attitude and Vernier Upper Module has a bipropellant propulsion system for orbital injection, and a monopropellant propulsion system for controlling the vehicle's roll and the attitude.

AVUM's primary mission begins at the end of the solid-propulsion phase, when it starts manoeuvring to reach the targeted deployment orbit with high accuracy. AVUM is designed to deliver different payloads into different orbits and to perform fine satellite pointing before separation. At the end of the mission, it is disposed of safely to limit orbital debris.

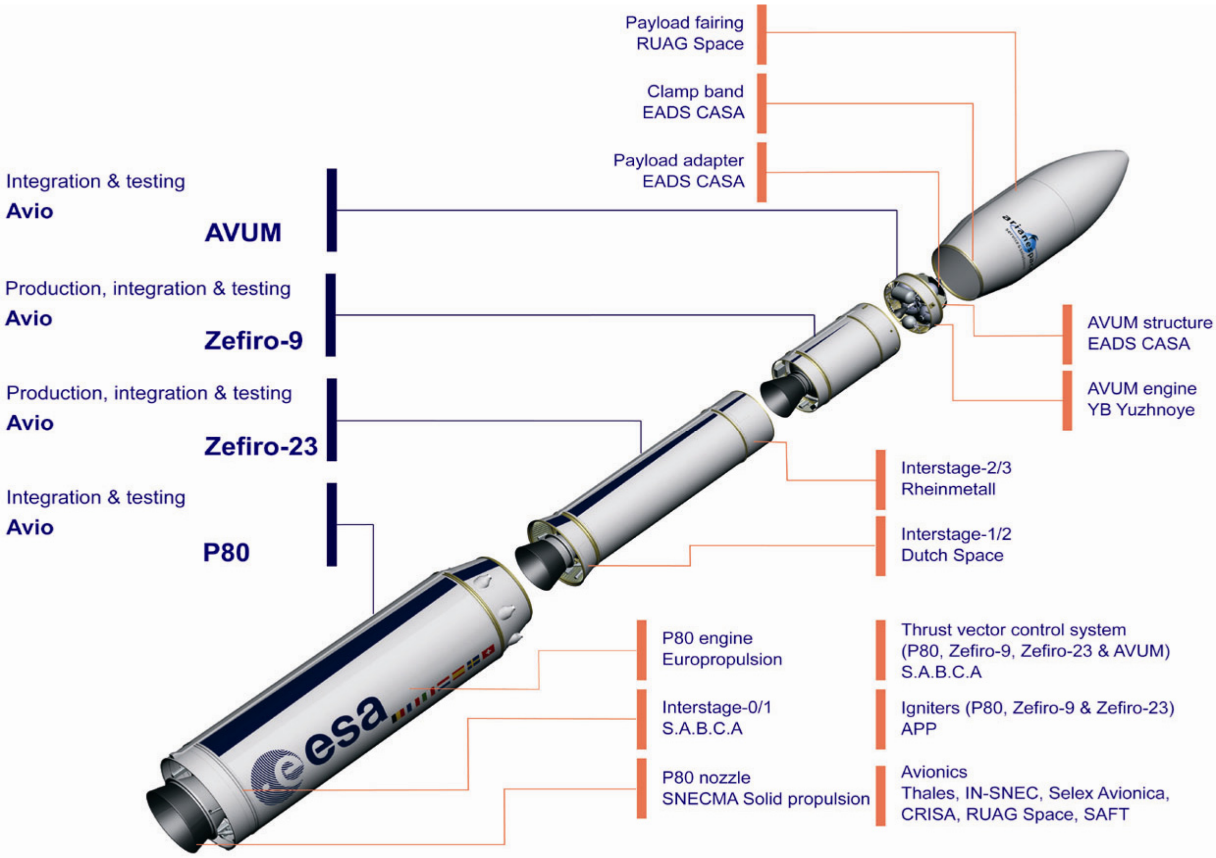
AVUM carries 550 kg of propellant (UDMH/NTO) in four tanks and is powered by a restartable 2.45 kN RD-869 engine. It incorporates two clusters of three monopropellant thrusters for roll and attitude control, and accommodates the Vega avionics module, which provides flight control and mission management, telemetry, flight termination, power supply and distribution.

1.5 The fairing and adapters

The 20 cu-m, 2.6 m-diameter composite fairing, made of 7.18 m-long half shells, protects the payload during the ascent through the atmosphere. The payload is mated to the launcher through a 937 mm-diameter adapter. Special adapters for multiple payload arrangements are under development.

Industrial team

Avio (Italy)	AVUM integration and test
Moog/Sabca	Thrust vector control
EADS Astrium CRISA (Spain)	AVUM avionics multifunctional unit
EADS Astrium Space Propulsion (Germany)	Roll attitude control system
EADS Astrium ST (France)	Flight software
EADS CASA (Spain)	AVUM structure and skirt, payload adapters
KB Yuzhnoye (Ukraine)	RD-869 engine and propulsion system
Ruag Space (Switzerland)	Fairing
SAAB (Sweden)	Onboard computer
SAFT (France)	AVUM batteries
Selex Galileo (Italy)	AVUM safety avionic unit
Thales (France)	AVUM avionics, inertial reference system
Zodiac Data Systems (France)	AVUM telemetry avionics unit



1.6 The launch facility

Like Ariane 5 and Soyuz, Vega is operated from the Guiana Space Centre, Europe's Spaceport in Kourou, French Guiana. Vega will benefit from the best launch infrastructure in the world, with a maximum extra velocity provided by Earth's spin at 5°N latitude for equatorial orbits, a wide range of accessible launch azimuths over the Atlantic Ocean to reach all orbital inclinations (from equatorial to Sun-synchronous), and state-of-the-art payload processing facilities.

The Vega launch pad (ZLV: Zone de Lancement Vega) was built on the old Ariane 1 pad (ELA-1), decommissioned in 1989. It is located some 1 km southwest from Ariane 5's ELA-3. The rebuilding work, led by prime contractor Vitrociset of Italy, started at the end of 2004. The concrete pad was modified to accommodate Vega and the new 50 m-tall Mobile Gantry (MG), weighing some 1000 tonnes, as well as a 32 m-high umbilical mast. Four 60 m-tall towers protect the pad from lightning strikes.

The vehicle's three solid stages and bipropellant module are stacked on the pad. The payload composite is mated on top of the vehicle some seven days before launch.

While on the pad, Vega and its payload are kept in a controlled environment. The MG is rolled back on its 80 m-long rail track only a few hours before launch.

The ZLV is designed to accommodate a launch rate of four missions per year.

The Vega Launch Control Centre (CDL) is in the same building that already houses the Ariane 5 CDL, 1.3 km from the ZLV.

Mission control is provided from the same Jupiter Building that already supports Ariane and Soyuz launches, 15 km from the pads.

2 THE VV01 MISSION

2.1 Purpose of the qualification flight

As the first flight of a new launch system, the VV01 mission is a qualification flight, aimed at demonstrating the nominal behaviour and performance of all of the elements of the launch system during the preparation phase of the launcher up to the flight and the separation of the payloads.

The qualification flight is the final step of an incremental qualification process that started with the development and qualification of various components, subsystems, stages and functions of the vehicle and of the ground segment, and ended with the verification of the interfaces between the vehicle, the ground segment and the launch base infrastructure, finally to pronounce the readiness for the first flight.

An impressive number of tests were performed progressively, from component to system level.
The qualification flight is the final confirmation of the design of the launch system and the final validation of the system models used for the mission definition in flight conditions.

The main qualification objectives for the launch vehicle include the liftoff kinematics with respect to the pad interfaces, the ignition, performance, flight control, thrust vector control and separation of all three solid stages, the fairing separation, AVUM performance and restart capability, payload release manoeuvres and accuracy and finally AVUM passivation at the end of the mission with a deorbiting manoeuvre to comply with debris mitigation policies.

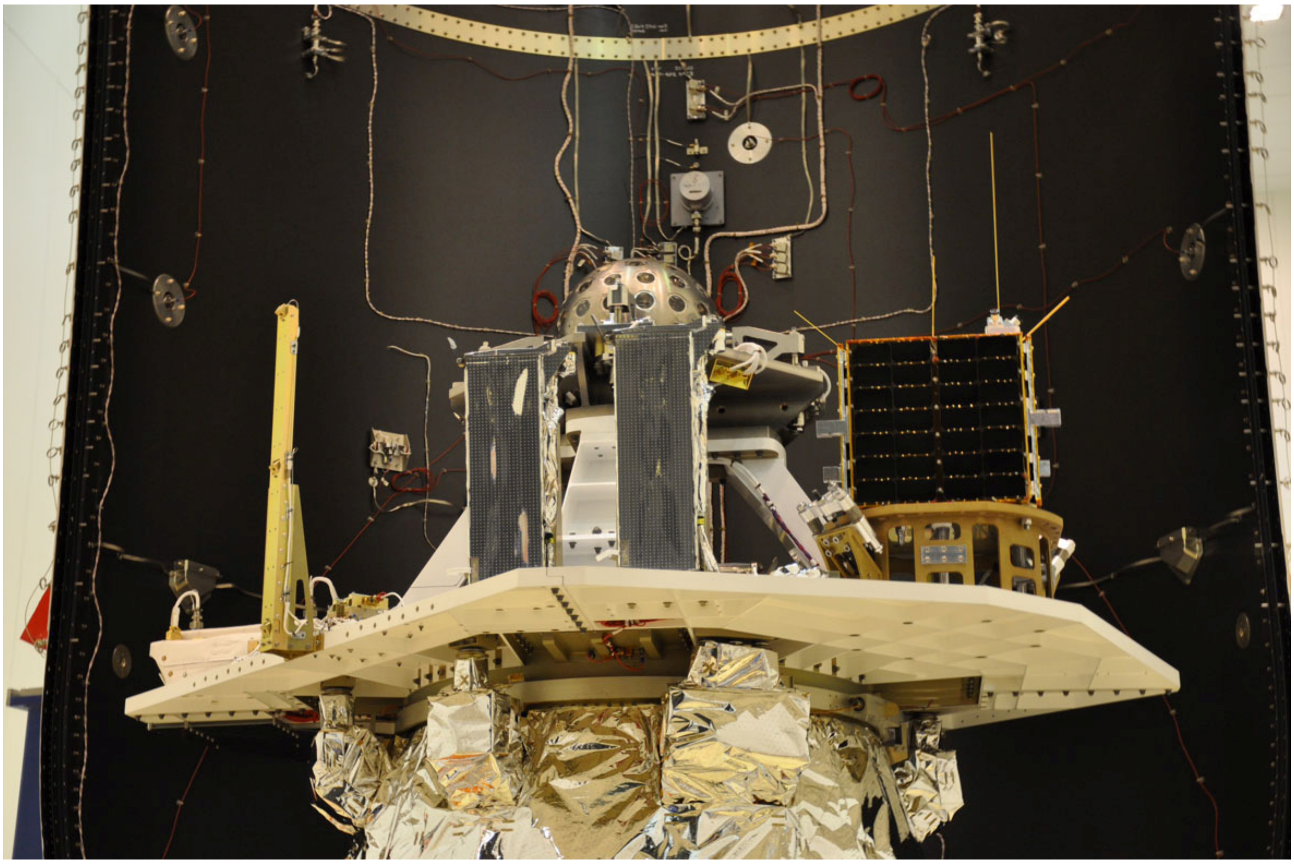
To monitor all these events during the flight, the VV01 launcher carries extra sets of sensors and three telemetry systems to download data in real time to the ground. These data will be processed after the flight to identify possible discrepancies. As a demonstrator for new technologies, the first stage has its own set of sensors with a dedicated telemetry system.

In order to prepare for future operational flights, the LARES payload platform carries a set of sensors, including accelerometers, acoustic sensors and cameras to monitor the payload environment during the flight.

The vehicle is not the only system to be qualified with this mission. All ground systems and launch procedures will be qualified simultaneously. This includes payload processing and integration, launcher acceptance via the readiness control checks with a simulated countdown and mission sequence, final prelaunch readiness checks via the automatic sequences during the final countdown, readiness check of the launch base and of all support means needed during the flight (weather forecast, telemetry downlink stations, tracking stations, flight termination).

2.2 The payloads

Although the maiden flight was foreseen as a single-payload mission, the collaboration between ESA and ASI allowed it to be upgraded into a multiple-payload mission. The primary payload for this qualification flight is the LARES satellite of Italy's space agency, ASI. The secondary mission covers the ALMASat-1 microsatellite from the University of Bologna and seven picosatellites from European universities.



LARES, ALMASat-1 and the seven CubeSats.

LARES (Laser Relativity Satellite) is a science satellite developed by ASI to study the 'Lense–Thirring effect' – a consequence of Einstein's general relativity – explaining precession of bodies' orbits in the vicinity of large spinning masses such as Earth.

The satellite, built by Carlo Gavazzi Space, is a passive 376 mm-diameter sphere made of tungsten alloy weighing about 400 kg. It features 92 cube corner retroreflectors for laser ranging from Earth. LARES will be released into a 1450 km-altitude circular orbit and will complement ASI's previous Lageos-1 and Lageos-2 laser geodynamics satellites, launched in 1976 and 1992, respectively.

The avionic in the LARES support structure is also in charge of powering the separation systems for the other payloads, driven by launch vehicle commands to the LARES avionics.

ALMASat-1 (Alma Mater Satellite) is a 12.5 kg technology demonstration microsatellite developed and built by the University of Bologne. It consists of a 30 cm cube designed as a modular structure that could be used for various technology demonstrations or Earth observation missions. On this first mission the main objective will be to test the key performance, such as 3-axis pointing accuracy, of this low-cost multipurpose bus in preparation for future missions.

To ensure its reentry within 25 years, ALMASat-1 will be deployed into an elliptical orbit with a perigee at 350 km.

Seven picosatellites sharing the same CubeSat design (1 kg, 1 W, 10 cm cubic structure) developed by universities from ESA member or cooperating states were selected within European universities on behalf of ESA's Education programme. They will be released by three P-PODs (Poly-Picosatellite Orbital Deployers) mounted on the LARES structure into an elliptical orbit with a 350 km perigee that will ensure their safe reentry within 12 years. These seven cubesats are:

e-St@r Developed by the Polytechnics Institute of Turin, Italy. It will test an active determination and control subsystem for 3-axis control as well as a set of commercial components and materials.

Goliat Developed by the University of Bucharest, Romania. It will perform Earth imaging with a 3-megapixel digital camera and conduct measurements of radiation and micrometeoroids in low-Earth orbit. This is Romania's first satellite.

MaSat-1 (Magyar Satellite) Developed by the Budapest University of Technology and Economics, Hungary. It will demonstrate a power conditioning system, a transceiver and an onboard data handling system. This is Hungary's first satellite.

PW-Sat-1 Developed by the Warsaw University of Technology, Poland. It will deploy a solar sail as a deployable drag augmentation device in order to accelerate the removal of picosatellites at the end of their missions. This is Poland's first satellite.

Robusta (Radiation On Bipolar for University Satellite Test Application) Developed by the University of Montpellier, France. It will study the effect of radiation on electronic components based on bipolar transistors for comparison with its own degradation models.

UniCubeSat GG Developed by the GAUSS astrodynamics group of the University of Rome 'La Sapienza', Italy. It will deploy two booms to demonstrate gravity-gradient stabilisation on a picosatellite. Each boom will carry a solar panel at its end to generate electrical power.

Xatcobeo Developed by the University of Vigo, Spain. It will test a software-defined reconfigurable radio and an ionising radiation measurement system. It will also test a solar panel deployment system.

2.3 Timeline of the launch campaign

Event	Date
Flight Readiness Review #1	13–14 Oct 2011
Arrival of Vega VV01 stages and LARES in Kourou	24 Oct 2011
Delivery of LARES to S1B payload processing facility	26 Oct 2011
Start of launch campaign	7 Nov 2011
P80FW transferred to the ZLV and installed on the pad	7 Nov 2011
Delivery of P-PODS and CubeSats in Kourou	late Nov 2011
Zefiro-Z23 stage stacked	2 Dec 2011
Flight Readiness Review #2	7 Dec 2011
Zefiro-Z9A stage stacked	9 Dec 2011
P-PODs integrated on LARES adapter	12–14 Dec 2011
AVUM integrated	16 Dec 2011
Final checkout	13 Jan 2012
Start of combined operations	19 Jan 2012
Upper composite mated	21 Jan 2012
First gantry rollback	26 Jan 2012
Countdown rehearsal	1 Feb 2012
AVUM propellant loading and pressurisation	3–6 Feb 2012
Launcher final preparation	12 Feb 2012
Launch day	13 Feb 2012

2.4 Timeline and flight profile of the mission

Event	Time	Altitude	Relative Speed
Start of synchronised sequence	–3 min 30 s		
P80FW ignition	**T0**	0 km	0 m/s
Liftoff	0.3 s	0 km	0 m/s
Transonic (Mach 1)	30.7 s	4.7 km	332 m/s
Maximum dynamic pressure	53 s	13 km	586 m/s
P80FW burnout and separation	1 min 54.8 s	60 km	1.7 km/s
Z23 ignition	1 min 55.6 s	61 km	1.7 km/s
Z23 burnout and separation Start of coast	3 min 22.3 s	127 km	3.8 km/s
Z9A ignition	3 min 38.5 s	135 km	3.8 km/s
Fairing separation	3 min 43.5 s	138 km	3.9 km/s
Z9A burnout and separation	5 min 47.1 s	182 km	7.7 km/s
AVUM 1st ignition	5 min 54.1 s	185 km	7.7 km/s
AVUM 1st cutoff Injection into transfer orbit	8 min 45 s	260 km	7.8 km/s
AVUM 2nd ignition	48 min 7.3 s	1447 km	6.6 km/s
AVUM 2nd cutoff Injection into first target orbit	52 min 10.5 s	1450 km	6.9 km/s
LARES separation	55 min 5.5 s	1450 km	6.9 km/s
AVUM 3rd ignition	1 h 6 min 10.5 s	1457 km	6.9 km/s
AVUM 3rd cutoff Injection into second target orbit	1 h 10 min 34.3 s	1458 km	6.6 km/s
ALMASat-1 and CubeSats separation	1 h 10 min 35.3 s	1458 km	6.6 km/s
End of mission	1 h 21 min 0.3 s	1344 km	6.7 km/s

2.5 The ground telemetry network

Acronym	Telemetry Station	Location
KAG	Kourou acq. Galliot	French Guiana
SNA	Station Navalisée Ariane	Atlantic Ocean
SMA	St Maria	Azores Islands, Portugal
SVB	Svalbard	Svalbard Islands, Norway
JEU	Jeju	South Korea
APE	Perth	Australia
MGS	McMurdo	Antarctica

3 THE VEGA PROGRAMME

3.1 Vega and the small mission launch market segment

In the late 1990s, with the advent of component miniaturisation and the development of the 'faster–better–cheaper' approach to reduce development cost and time, space agencies around the globe started developing small satellites. Europe joined the trend with a new family of missions such as the Earth Explorers (four launches since 2005).

In the meantime, commercial communication satellites have continued to grow in size and mass, and led the Ariane launch system to a range of performance in payload capacity no longer compatible with small science and Earth observation missions.

In the years following the collapse of the Soviet Union, large quantities of decommissioned ballistic missiles became available for refurbishment into low-cost small-satellite launchers such as Rockot and Dnepr. For years, the availability of such affordable vehicles prevented the development of competitive launch solutions in this market segment, even driving existing US launch systems out of the international market.

However, the era of refurbishing missiles into launch vehicles is coming to end as the stockpiles are depleted and the cost of maintaining or refurbishing old missiles into flightworthy hardware is increasing.

To maintain a competitive and independent access to space for this new range of missions – which will become increasingly strategically critical in the near future with the advent of new satellite series such as the Sentinels – it became paramount for ESA to develop its own small satellite launch system.

The Vega launch system is designed to offer a reliable, flexible, regularly available and maintainable capacity to lift such missions into space. Once qualified, Vega will be operated commercially by Arianespace in the European and the international launch markets, where its competitive advantages will provide an edge against ageing rival systems.

Moreover, Vega is an evolutionary system that could later be adapted to meet evolution in demand.

The first commercial launch contract for Vega was signed on 14 December 2011, by ESA and Arianespace, for the launches of two Sentinel satellites and preparation of the suborbital flight of the IXV demonstrator.

3.2 Decision history and funding

The Vega programme has its roots in Italy's operations of US-built Scout launchers in cooperation with NASA from the Italian San Marco platform, anchored off the coast of Kenya from 1967 to 1988.

In 1977, the University of Rome began studying technical options to improve Scout. In the late 1980s, concepts for a Scout 2, adding Ariane solid strap-on boosters (AAPs) from Ariane 3 to a Scout G1, were studied with Avio's ancestor, BPD.

In 1992, as the US Scout production line was closed down, the project continued as a sole Italian venture under the name San Marco Scout, led by ASI and Avio and based on a new series of Zefiro rocket motors. It was eventually renamed Vega (*Vettore Europeo di Generazione Avanzata*, or advanced generation European vehicle) in mid-1993, when ESA and its industrial partners began study concepts for various Ariane 5 complementary launchers.

The first decision towards the Europeanisation of Vega was taken by ESA's Council, meeting at Delegate level in June 1998 in Brussels. The final decision to start development activities was taken by the ESA Launchers Programme Board on 27–28 November 2000; the programme officially started on 15 December 2000, when seven states committed to its funding.

Several configurations of the launcher were analysed during the preparation activities that ended up in February 2003, when the contract for its development and qualification was signed between ESA and ELV SpA. The contract for the development and qualification of the ground segment was signed in 2005 between ESA and Vitrociset.

Contributions to Vega and P80FW development

Belgium	6.9%
France	25.3%
Italy	58.4%
The Netherlands	3.2%
Spain	4.6%
Sweden	0.6%
Switzerland	1.0%
Total	100%

The Vega programme is managed under the responsibility of ESA, by an Integrated Programme Team at ESA's ESRIN centre in Frascati, near Rome. ESA, CNES and ASI staff participate in this team, which receives technical support from ESA's ESTEC technical centre and the Launchers Directorate (DLA) of CNES.

The launcher industry team is led by ELV SpA, a joint venture of Avio (70%) and ASI (30%). The ground segment industry team is led by Vitrociset.

Within the Vega programme, the P80FW development project was led by a joint ESA/CNES/ASI team, now located in Paris, with Avio as prime contractor and programme delegation to Europropulsion.
In total, the development of Vega will have cost some €710 million funded through ESA contributions, and about €76 million through direct industrial investment by Avio in the development of the P80FW.

3.3 Development timeline

1998	
22 Jun	Z16 first ground firing test (success)
24 Jun	ESA council approves the Vega programme
1999	
17 Jun	Z16 second ground firing test (success)
2000	
19 Dec	Vega's funding is approved
2001	
21 Feb	ASI and Fiat Avio incorporate ELV
2002	
Jun	Launcher Preliminary Design Review
2003	
25 Feb	ESA contracts with ELV for launch vehicle development and qualification
2004	
20 Oct	Start of the ELA1 refurbishment work into ZLV
2005	
20 Dec	Z9 first ground firing test (success)
2006	
23 May	Ground Segment System Design Review
26 Jun	Z23 first ground firing test (success)
30 Nov	P80FW first ground firing test (success)
Dec.	Critical Design Review
2007	
28 Mar	Z9 second ground firing test (nozzle failure)
4 Dec	P80FW second ground firing test (success)
Dec	Fairing qualification
2008	
27 Mar	Z23 second ground firing test (success)
23 Oct	Z9A first ground firing test (success)
Dec	Z23 stage qualification.
2009	
28 Apr	Z9A second ground firing test (success)
2010	
Feb	AVUM stage qualification (structure and propulsion).
Apr	Payload adapter qualification
25 May	Z9A VERTA ground firing test (success)
Jul	Kickoff of the Launch System Combined Tests campaign
Nov	Z9A stage qualification
2011	
11 Feb	Completion of the functional mockup launcher integration on pad
Apr	Dry run
30 Sep	Ground Segment Technical Qualification Review
3–7 Oct	Launch System Operational Readiness Review
13–14 Oct	Flight readiness review
7 Nov	Start of VV01 launch campaign
2012	
13 Feb	Qualification flight

3.4 The VERTA programme

The Vega Research, Technology & Accompaniment (VERTA) programme was approved by ESA's Council in December 2005, during ESA's Ministerial Conference in Berlin. It is a three-fold programme to support and secure the initial operations of the Vega launch system.

First, it includes the procurement of five Vega launches for ESA, to ensure an initial exploitation phase at a launch rate of at least two flights per year.

Under the current schedule, these launches are due to carry a set of small science and technology payloads together with the Proba-V remote sensing satellite in early 2013, the ADM-Aeolus satellite to probe the atmosphere in late 2013, the LISA Pathfinder science mission demonstrator in 2014 and the Intermediate eXperimental Vehicle (IXV) reentry demonstrator in early 2014. A payload flight opportunity remains available for the fifth launch. Production contracts were signed in 2010 for these five launchers.

Secondly, VERTA covers the development of complementary services and hardware, such as a multiple-payload launch capacity and new payload adapters tailored for Vega's specific markets.

Finally, VERTA provides a framework for component testing in order to mitigate risks for production drifts and to enable the qualification of new technologies to prevent obsolescence. In this role, VERTA is the equivalent of Ariane 5's ARTA-5 Ariane Research, Technology & Accompaniment programme.

As such, VERTA includes ground-firing tests of Vega's solid rocket motors as well as production sampling and testing on a regular basis. These activities started in 2006 and have contributed, through tests and additional analysis, to increasing the robustness of the ground qualification of the Vega launch system.

VERTA is supported by contributions from the same countries contributing to Vega's development (Italy, France, Spain, Belgium, the Netherlands, Switzerland and Sweden) with an envelope budget of €400 million covering the five flights and accompaniment activities to 2014.

Contributions to VERTA

Belgium	5.6%
France	24.1%
Italy	57.8%
The Netherlands	2.5%
Spain	7.7%
Sweden	0.7%
Switzerland	1.6%
Total	100%

3.5 The partners and their roles

ESA

As for all its other programmes, the European Space Agency is responsible for the implementation of the programme and of its technical and financial management. Its technical supervision is founded on its 30 years of experience. The decisions by ESA and the participating states provide the formal base for Vega's integration into the European space transportation fleet and its long-term access to the institutional market. ESA heads the integrated Vega programme team and owns the ZLV facilities.

ASI

Since Italy is providing more than 50% of the overall funding for the Vega programme, the Italian space agency plays a significant management role through the integrated Vega programme team at ESA's ESRIN centre in Frascati, near Rome. It owns 30% of ELV SpA.

CNES

The French space agency, CNES, has led the project team for P80FW development. It also contributes to the integrated programme team in ESRIN and provides technical support for developing the launcher and ground segment. CNES has been also highly involved, as test executor, in the combined tests campaign. CNES teams are also involved in the launch campaign in support of the Vega Integrated Project Team.

Arianespace

As it already does for Ariane and Soyuz, Arianespace holds exclusive rights to market and sell Vega launch services. Once Vega is qualified, operating the Vega launch system will be under the responsibility of Arianespace. Arianespace teams have been supporting the development and qualification of the launch system and are highly involved in the launch campaign.

ELV

The ELV SpA company was incorporated in 2001 to manage Vega's development and production, with industrial architect responsibility. ELV is responsible for the delivery and integration of Vega launchers. As industrial prime contractor, ELV is in charge of acceptance of the launcher's components and integration at the launch site. As launcher's design authority, it also participates in final preparations and launch operations.

Avio

As prime contractor for all three solid-propellant stages of Vega and integrator of AVUM, Avio is the primary industrial partner of the Vega programme. It also owns 70% of ELV SpA.

Vitrociset

Under contract from ESA, Vitrociset is prime contractor for the Vega ground segment.